CHAPTER V

SUMMARY AND CONCLUSIONS
The present study has been undertaken to determine the effects of a lead mining operation on the environmental ecosystems and to delineate plant – soil – water relationships near Bandalamottu, Guntur district, Andhra Pradesh, India.

1. To screen certain dominantly growing accumulator plant species in the mining region, through analysis of plant tissues and associated soils for trace element accumulation.

2. Decontamination of polluted soils is designed to better understand the interplay of biogeochemical process in the subsurface environment. It is emerging as most alternative technology for removing the pollutants from the environment, reclaiming, restoring much polluted sites and preventing further pollution. Bacteria will use many naturally occurring and synthetic wastes as sources of carbon and energy. Thus reducing organic wastes to less toxic metabolites.

3. The ground water samples were collected in the Bandalamottu area and analyzed for its major chemical constituents and studied for its suitability for drinking and agricultural purposes.

The study has been divided into: (1) Introduction (2) Plant biogeochemistry (3) Remediation of contaminated soils and (4) Hydrogeochemistry.
5.1 INTRODUCTION

Bandalamottu mineralized belt (Lat. 16° 13' 15" N: Long 79° 39' 47" E) is located in Vinukonda Taluk of Guntur District, Andhra Pradesh. It is included in the survey of India toposheet No. 56 P/12. The geological formations in the study area include Nallamalai series of the Upper Cuddapah group comprising quartzites, phyllites and limestones. The base metal deposits such as copper, lead and zinc are localized in dolomitic limestones and coarse grained calcareous quartzites which occur in the form of intercalations with argillites and phyllites. The present study has been undertaken to investigate the environmental studies involving the plants, soils, and ground waters in Bandalamottu – Agnigundala mineralized belt.

The study is basically classified into plant biogeochemistry, remediation of contaminated soils and hydrogeochemistry. Biogeochemistry involves the study of plant tissues of dominantly occurring plant species and their associated soil. Remediation includes decontamination of contaminated soils and hydrogeochemistry deals with the chemical characteristics of ground water.

5.2 PLANT BIOGEOCHEMISTRY

A biogeochemical survey provides geochemical information on the soil substrate not provided by other surficial materials. The composition of vegetation reflects (a) the availability of an element in the vicinity of the root system and (b) the ability of plant to absorb, transport and accumulate an element. Procedures for conducting biogeochemical surveys involve the dynamic nature of living plants giving rise to variations in plant chemistry. Each plant species has its own requirement and tolerance to element uptake and retention. Thus, the composition of an individual plant varies substantially among its tissues (i.e., roots, wood, bark, twigs, leaves and flowers).
Plants accumulate most trace elements and are sensitive indicators of chemical environment in which they survive. To determine element distribution, vegetation provides a more representative sample medium than conventional clastic geochemical sample medium. Preliminary studies are intended to screen the predominately grown plant species, provides insight into the allocation and compartmentalization of trace elements in the plant species, which provides further in site into management aspects. This minimizes environmental risks and replenishes the terrestrial and aquatic ecosystems and creates an aesthetically pleasing and hygienic environment.

Mining activities generate a large amount of waste rocks and tailings, which get deposited at the surface. The disintegrated soils, the waste rocks and tailings are often very unstable and will become sources of pollution. The present study deals with the accumulation of heavy metals viz., Pb, Cu, Zn, and As in plants developed on mine dumps. The plant species include mainly Albizia amara, Erthroxylum monogynum, Calotropis gigantea, Zizyphus numelaria, Acacia torta, Helecrinutes Isona, Grewia Flavescens, Wrightia tinctoria, and Azadirachta indica are the dominant species that vastly grow over the lead mining soil heaps of the Bandalamottu lead mining area. Chemical analytical data show that these plants can accumulate huge amounts of lead and arsenic in both leaves and twigs.

The uptake and translocation mechanisms and accumulations of various metals by plants are different for different species. Highest average concentration of 1783 (µg/g) of Pb is accumulated in the twigs of Wrightia tinctoria. Similarly 5358 (µg/l) of arsenic is accumulated in the leaves of Calotropis gigantea. Of all the plant species studied W. tinctoria has accumulated large amounts of Pb and Cu in both the organs.
Leaves of *H. isora* have accumulated huge amounts of zinc with a mean value of about 671 (μg/g). All these lines of evidence suggest that these plant species can serve as pioneer species of reclamation of lead mined area and can be used as model plants for investigation and plant tolerance mechanisms.

It is proposed that the plant species *Wrightia tinctoria*, *Calotropis gigantea* and *Heloceres isora* can be used for reclaiming tailings in the lead mining area of Bandalamottu. Further, biological absorption coefficient has indicated the biogeochemical behaviour of Pb, As and other trace elements in the Bandalamottu Lead mining region.

The most successful populations at each site were those with highest tolerance to the metals occurring on the waste, provided the species was appropriately adapted to the other soil conditions. In higher plants, the ability to accumulate the elements and survive on mine spoils containing toxic quantities of various heavy metals occurs sporadically throughout different genera. So, these plant species must have developed tolerance mechanisms which enable them to survive on the toxic soils. The plants must be tolerant to toxic metals and should be ideal pioneer species to accelerate ecological succession of man-made habitats. In all cases tolerance has been shown to be element specific although plants from mine wastes which contain multiple toxicities have evolved tolerance to all of the metals involved. Because of the diversity of heavy metals present in many ore bodies and the diverse range of heavy metal dispersion mechanisms, it would, therefore, follow those environmental managers at mine sites, who are responsible for impounded mining wastes, must be as well versed in the biogeochemical cycling and accumulation of these metals.
5.3 REMEDIATION OF CONTAMINATED SOILS

The main objective in the present study is to reduce the environmental risk in terms of bioremediation. However, the use of chemical analysis to demonstrate a risk reduction through the disappearance of pollutant is insufficient, since toxic pollutants undetected by chemical analysis may be formed. Further, remediation of contaminated land takes into account the different groups involved in contaminated land management and offers a flexible learning approach based on practical experience and research.

The remedial measure for eliminating or confining sources of pollution or for the remediation and reclamation of contaminated soils are more frequently being adopted. The laboratory investigation is aimed at identifying low cost metal immobilizing agents such as certain industrial waste products, we explored the possibility of using red mud, pulverized fly ash and bone meal. Often remedial measures required to clean up sites contaminated with heavy metals are so complex that their implementation becomes economically unsustainable. In these cases immobilization of the metal contaminants, by means of suitable soil amendments is a promising and economically feasible technique for soil remediation.

In this chapter, the completion of manipulation of experiments, biosensor data was compared to chemical analysis data. Results proved conclusively that genetically modified bacterium was effective means of assessing the nature of contamination. A focused approach was adopted where by a series of simple manipulations were used to dissect and identify pollutants into a broad range of categories.
The potential of pulverized fly ash produced in immobilizing the heavy metals contained in severely contaminated soils has been experimentally assessed. The results obtained so far demonstrate that relatively small additions of fly ash can drastically reduce the heavy metal content of the soil leachates. Further, the lux-modified biosensor reports on the overall metabolic activity by the expression of bioluminescence. Remediations of contaminated soils have indicated that biosensor-based ecotoxicity was most powerful when carried out in combination with chemical analyses.

5.4 HYDROGEOCHEMISTRY

The mining and metallurgical processing of copper ore generates vast quantities of mine rock and mine tailings. The natural occurrence of copper, zinc and lead at Bandalamottu and its commercial exploration potentially threatens local ground water resources due to the leachate from the waste. Due to the lack of surface water bodies, the inhabitants at Bandalamottu area depend on ground water resources for drinking and agriculture. Surprisingly little attention has been given to this issue until recently. The natural chemistry of ground water is controlled largely by the dissolution of the geologic materials through which the water flows. Contaminants can enter ground water by a variety of means, but most commonly from resources at the ground surface. The dominant processes that influence the migration of contaminants in a particular region depend on the geological and geochemical conditions, as well as the chemical and biological characteristics of the contaminant. Mine waste can generate elevated levels of sulphate, metals and acidity. Unless mine waste sites are protected from oxidation and metal release, these sites represent a source of serious contamination to ground water and aquatic systems for potentially hundreds to thousands of years.
Determination of physical and chemical quality is essential for assessing the suitability of water for various purposes like drinking, domestic, industrial and agricultural purposes. Chemical analysis forms the basis of interpretation of the quality of water in relation to source, geology, climate, and use. Water being an excellent solvent, it is important to know the geochemistry of dissolved constituents and methods of reporting analytical data.

It is therefore essential to conduct field and laboratory investigations to characterize, understand, and interpret observed anomalies in ground water in the regional context. In this area, forty samples of groundwater were collected to study the chemical quality of waters present in the region. Chemical parameters like pH, specific conductance (EC), total dissolved solids (TDS), hardness, alkalinity, calcium, magnesium, sodium potassium, bicarbonate, carbonate, fluoride, chloride and sulphate were analysed by adopting the standard procedures of water analysis. The surfer contour map diagrams were constructed for these parameters. To know the suitability of waters for drinking and irrigation, parameters like Non Carbonate Hardness (NCH), Sodium Adsorption Ratio (SAR), integrated effect of EC and SAR, Percent Sodium, Potential Salinity, Residual Sodium Carbonate, Permeability Index (PI), Indices of Exchange (IBE), Kelly’s Ratio, Magnesium Ratio and Gibbs Ratio were determined.

The ground waters in the study area are alkaline in nature with greater mineralization and possess very hard waters. They possess low buffering capacity and high sulphate levels. Based on the classification of total dissolved solids as suggested by Gorrel (1958), all the water samples are fresh water category.
The Piper's diagram confirms that all the ground waters in the study area are characterized as alkaline earth's (Ca + Mg) exceeds alkalies (Na + K) and all the ground waters in the study area described as weak acids (CO₃ + HCO₃) exceed strong acids (SO₄ + Cl + F); all the samples of the study area are characterized as strong acids exceed weak acids and all the samples are characterized as carbonate hardness (secondary alkalinity) exceeds 50%. This is due to the dolomitic rocks which are responsible for release of chemical elements into the groundwaters of the Bandalamottu area.

Richard's classification of sodium adsorption ratio proposes that the ground waters of the study area are excellent for irrigation. The graphical diagram of irrigated water (U.S. Salinity Laboratory, 1954) and the integrated effect of EC and SAR conclude that the ground waters of the study area reveals that 15% of the ground waters possess medium salinity with low sodium, 65% of the ground waters possess high salinity with low sodium and 20% of the ground waters possess high salinity with medium sodium. Further, these waters are rated as satisfactory for agricultural purposes.

The Wilcox diagram (percent sodium versus conductivity) illustrates that the ground waters in the study area shows that 52.50% samples are "Good to permissible", 15% samples are "Excellent to good" whereas remaining 32.50% of the samples are "Permissible to doubtful".
The classification of residual sodium carbonates as suggested by U.S. Salinity Laboratory (1954) elucidates that the ground waters in the study area depicts that 37.50% samples are of safe for irrigation, 27.50% samples are marginal in quality and remaining 35% of the samples comes under unsuitable for irrigation.

The permeability index classification as per Doneen (1964) delineates that the ground waters in the study area are good for irrigation with 75% or more of maximum permeability. The indices of Base Exchange conclude that all the ground waters in the study area shows that majority of the samples fall in the negative zones indicating the exchange of Mg and Ca of the water with Na and K of the rocks.

The Kelly's ratio proposes that the ground water in the study area shows that 57.50% of samples suitable for irrigation and remaining 42.50% are unsuitable for irrigation. The magnesium ratio of the ground waters in the study are reflect that 98% of the water samples possess magnesium ratio more than 50% and hence the continuous application of these waters for agricultural purposes may turn the soils more alkaline and ultimately affect the crop yield. The Gibbs ratio diagram elucidate that the ground waters of the study areas are influenced by the rocks in the aquifers.

The overall quality of waters in the study area rules out any pollution from extraneous sources. Permanent hardness and Salinity are main characters of Bandalamottu region. The lithology is responsible for the release of elements predominantly in large amounts to ground water. These cations are solubilised and removed by leaching, leaving a residue deprived of its easily soluble bases.
CONCLUSIONS

The present investigative work at Bandalamottu has clearly demarcated the accumulation potential of the certain plant species viz., Wrightia tinctoria, Calotropis gigantea, and Helecteres isora. These plant species can profitably be utilised in the reclamation and re-vegetation of adversely affected mining environments of Bandalamottu mining area.

Remediation of soil has shown that fly ash can drastically reduce the heavy metal content of the soil leachates. The lux-modified biosensor reports on the overall metabolic activity by the expression of bioluminescence. E-coli is an extremely sensitive biosensor that can tolerate a wide range of heavy metal concentrations. Further, the results proved that the genetically modified bacterium was an effective means of assessing the nature of contamination.

The groundwater studies in the study area suggest that the enrichment of chemical elements sodium, potassium, calcium, magnesium, chloride, sulphate, carbonate, bicarbonate and fluoride is due to the lithology and environmental factors in the process of genesis. In the present study, permanent hardness, salinity and pollution are due to the larger residence time of groundwater, greater rock-water rock interaction, and greater solubility of minerals. The prevailing geological conditions have caused problematic levels of sulphate in the aquifers. Reducing sulphate concentrations significantly is not simple, but nonetheless, treatment plants should be set up to treat the mine water and community drinking water supplies to reduce the sulphate levels.

The programme initiated for this research work, as described above, provides an adequate base line for any future study intending to monitor the impact of the base metal deposits and the study also suggests the ways and means through which the quality of the ecosystem can be maintained.